

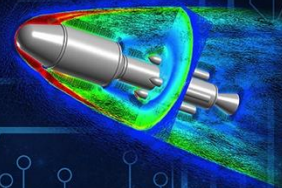
National Aeronautics and Space Administration



A Synergistic Use of Flight/Ground Testing and Simulations: An Airframe Noise Perspective

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Background



- ❑ **An important goal of NASA is to significantly reduce the environmental impact of civil transport noise**
 - The Environmentally Responsible Aviation (ERA) project aims to develop the enabling capabilities/technologies that will allow prediction/reduction of aircraft noise
- ❑ **Aircraft noise is comprised of two primary components**
 - Propulsion (engine) noise and airframe noise
- ❑ **Airframe noise is most prominent during approach to landing**
 - landing gear
 - slotted slats
 - flap and slat side edges
 - flap and slat tracks
 - spoilers
 - component (e.g., gear-flap) interaction





NASA-Gulfstream Partnership

Objectives

- Mitigate radiated **airframe noise** during aircraft landing
- Develop effective noise reduction (NR) concepts applicable to current and future generations of civil transport

Execution Plan

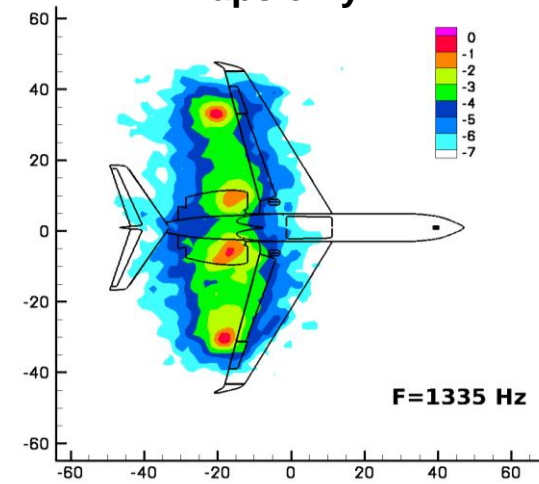
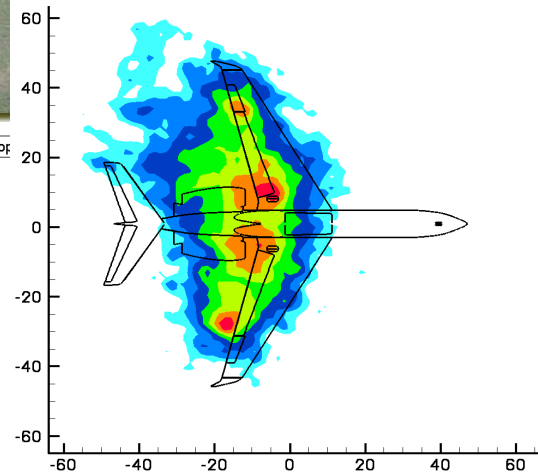
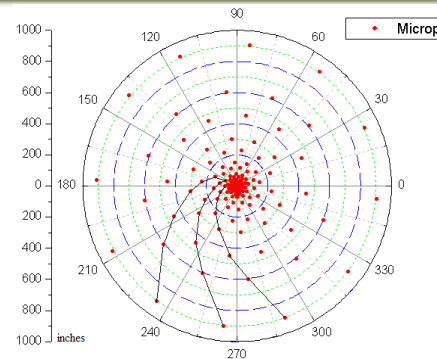
- Utilize **flight tests**, **wind-tunnel experiments**, and **computational simulations** to:
 - » Better understand the principles of airframe noise generation
 - » Improve airframe noise prediction tools
 - » **Develop efficient noise reduction concepts**
- Evaluate the most promising noise reduction concepts in a realistic environment (full scale flight test)

NASA-Gulfstream Airframe Noise Flight (2006)

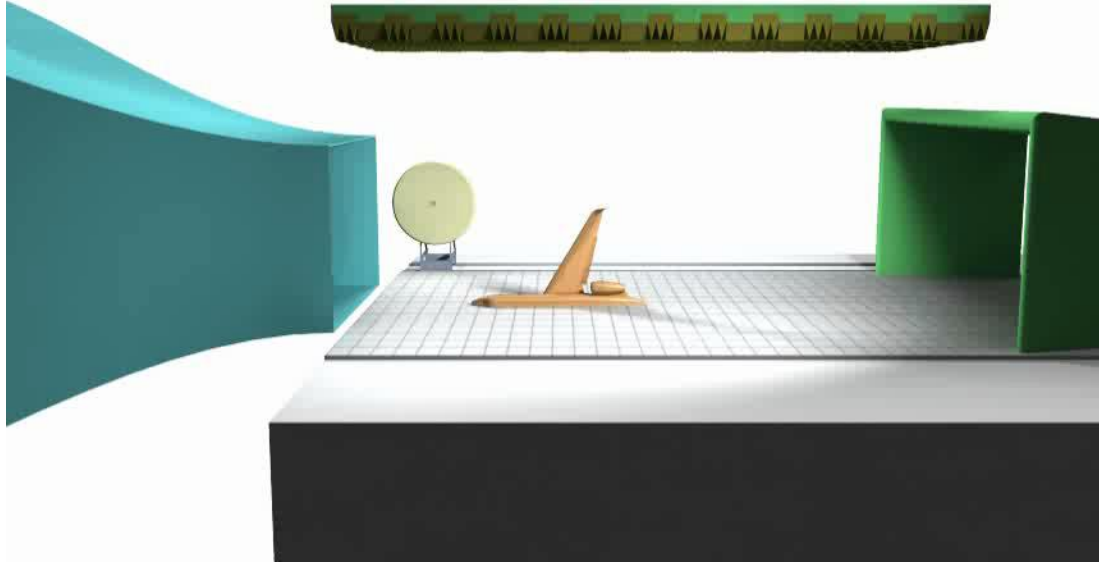


Main Gear and Flaps only

Flaps only



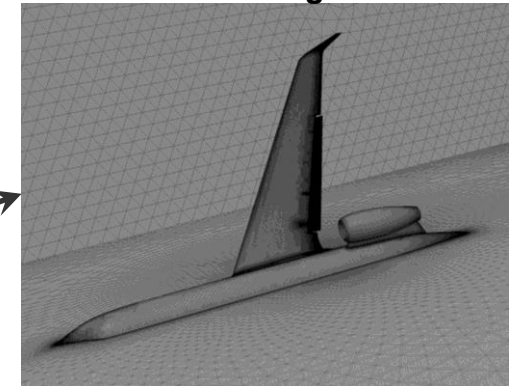
Wind Tunnel Tests and Corresponding Simulations



18% Scale Gulfstream Aircraft Model

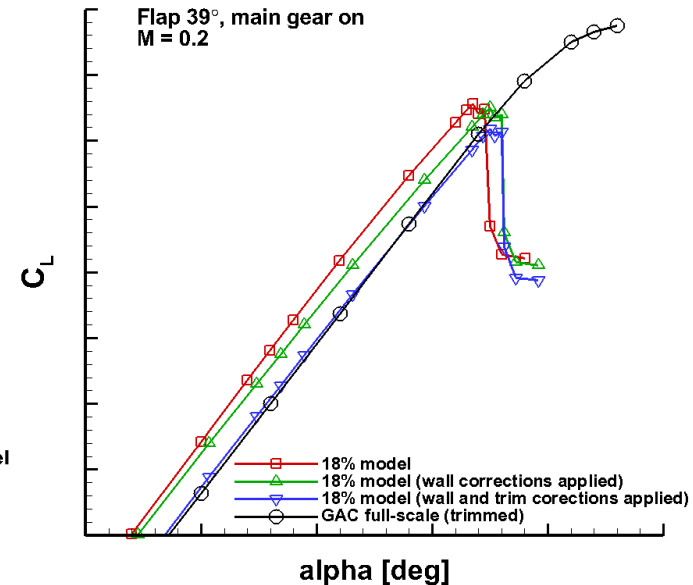
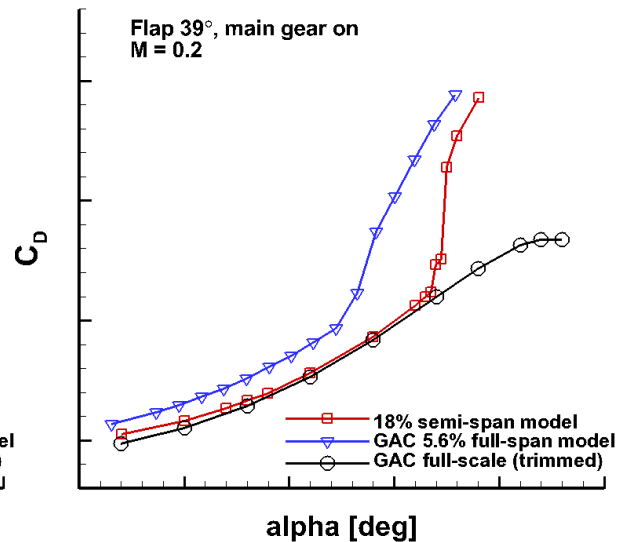
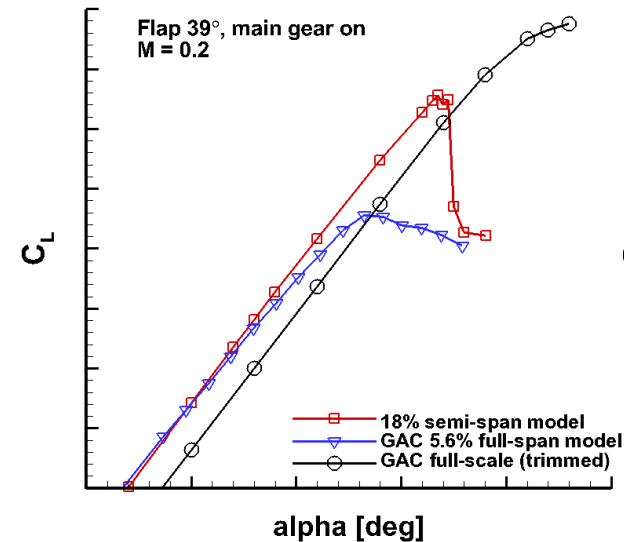


Simulated Configuration

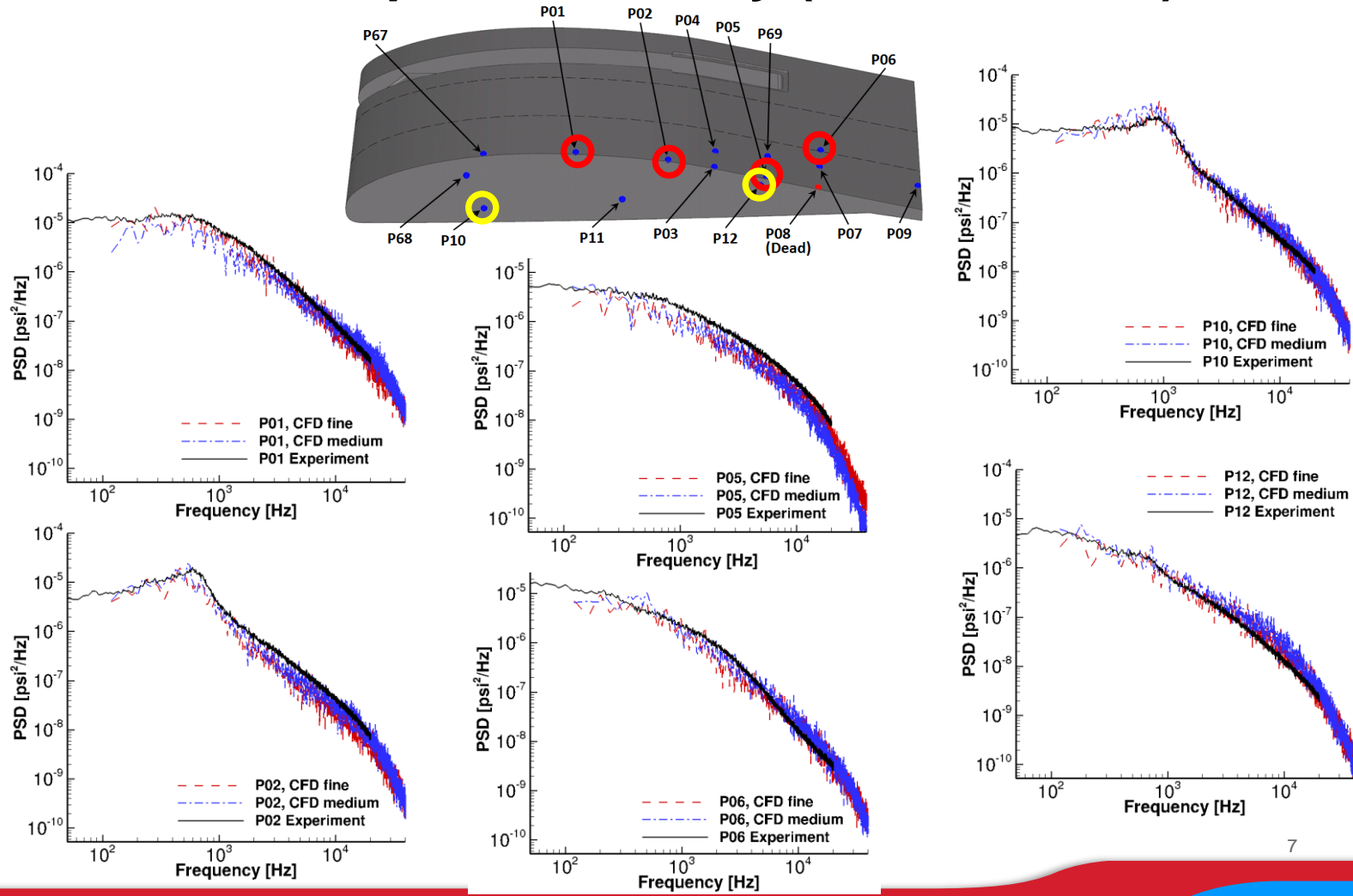


- NASA Langley FUN3D and Exa Corporation Codes
- Executed on NASA Pleiades supercomputer
- Animations by NAS Visualization Group

Global Forces (Lift and Drag Coefficients)



Unsteady Surface Pressures at Flap Inboard Edge Power Spectral Density (Main Gear on)



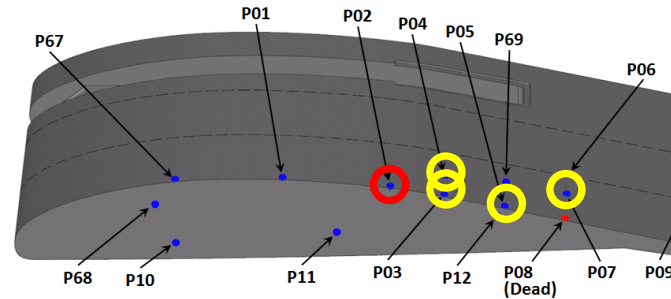
Aerodynamic Flight Test (Gulfstream)



- Flight test performed during March 2013
- Acquired data was used to address:
 - Reynolds number effects
 - Geometric fidelity effects
 - Installation effects
- Critical aircraft components instrumented
 - Pressure belt on wing (steady pressures)
 - Flap (steady and unsteady pressures)
 - Main and nose landing gear (unsteady pressures)
 - Pressure transducers identical as those used on 18% scale model

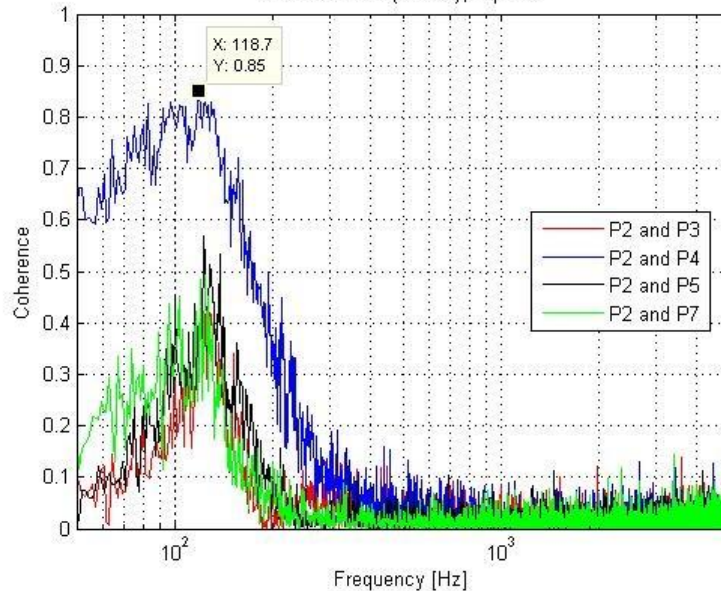


Unsteady Surface Pressures at Flap Inboard Edge Coherence Data (Main Gear Up)

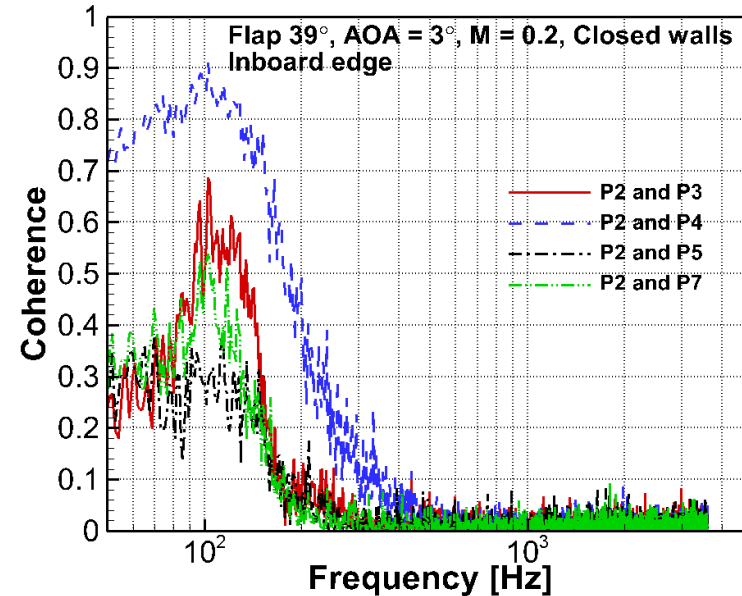


Flight test. GAC

FL783-Card 3B(130kts), flaps 39

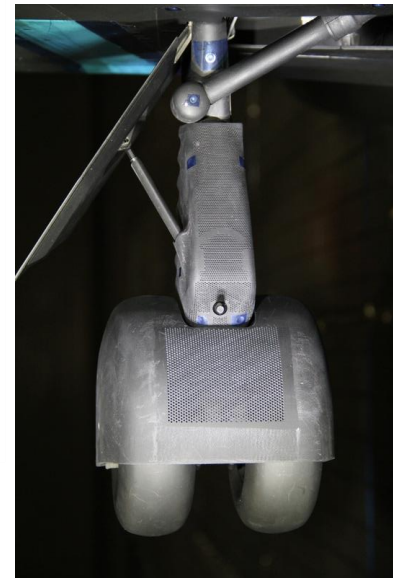


14x22 test, NASA



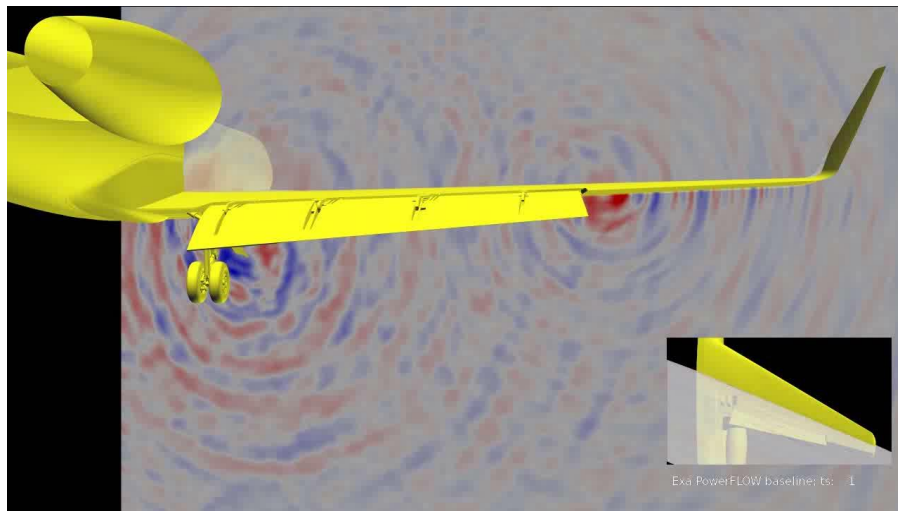
Low Noise Flap and Landing Gear

- Targets noise generated at aircraft flap tips and landing gear
- Circular and non-circular metallic fins (flaps) and porous fairings (gear)
- Effectiveness of concepts was validated/evaluated via simulations and testing

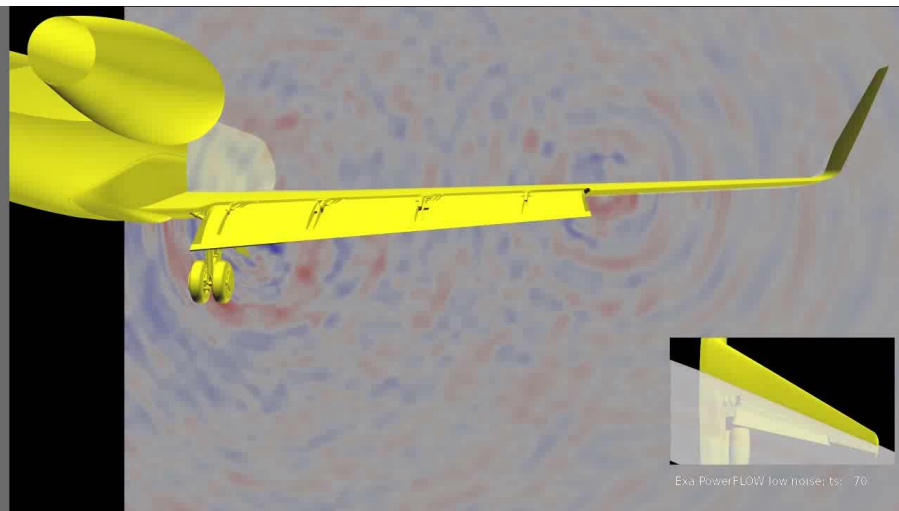


Baseline Comparison with Low Noise Case (Far View of Radiated Acoustic Field)

Baseline Configuration



Low Noise Configuration



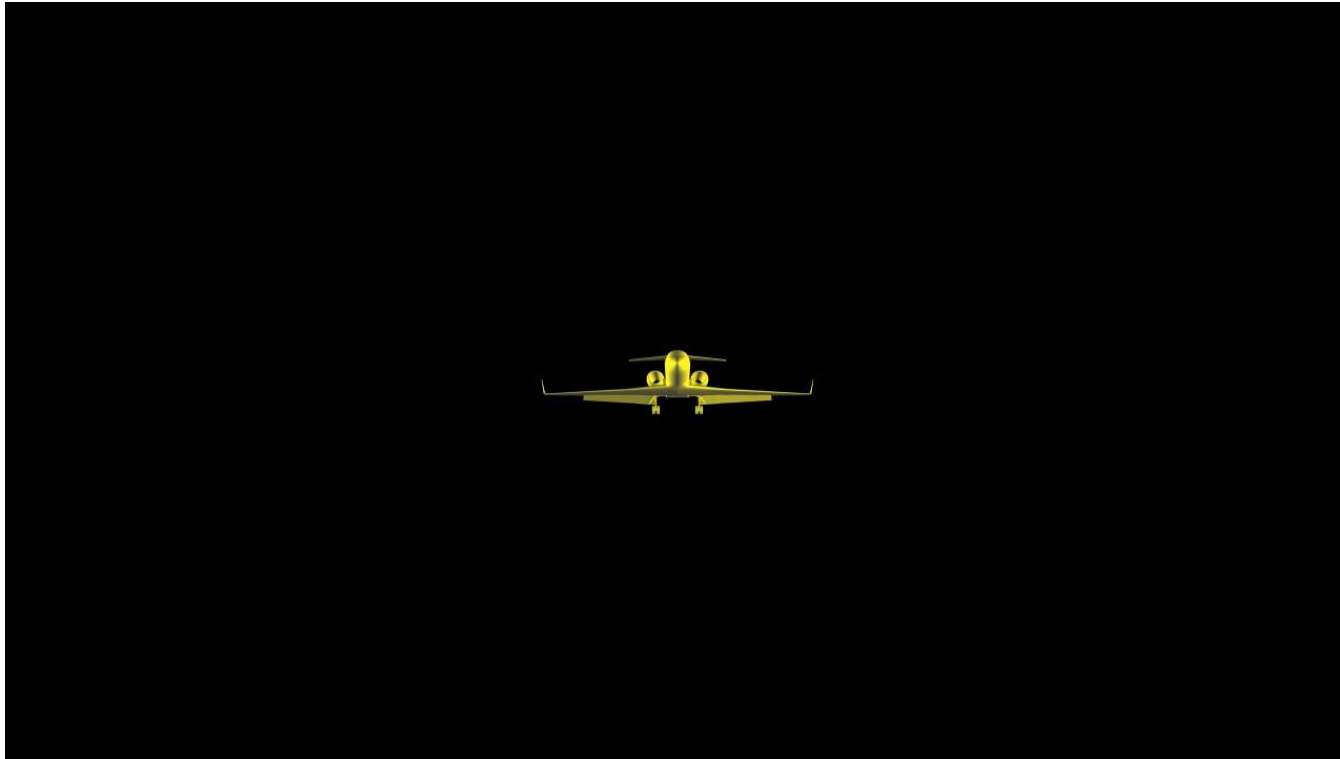
Simulation Characteristics

- As-built 18% scale high-fidelity Gulfstream model
- $Re = 3.47 \times 10^6$ based on MAC
- Solver: Exa Corporation PowerFLOW® (LBM)
- Finest resolution: 3×10^9 cells, 4000 cores, 1×10^6 CPU hours (NASA Pleiades)

Baseline Full-Scale Aircraft Configuration



Radiated Noise From Full-Scale Aircraft (Baseline)



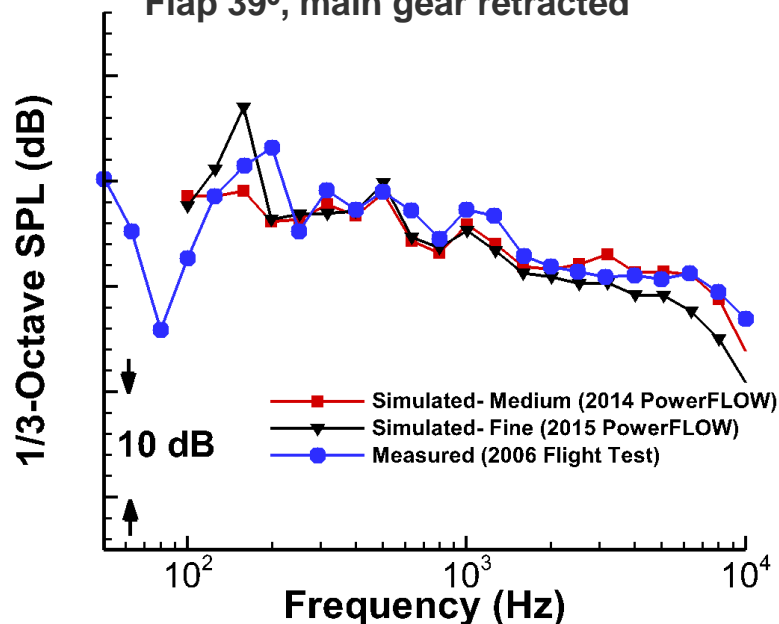
Simulation Characteristics

- Full scale Full Gulfstream Aircraft
- Re equivalent to 50% of flight: $Re = 10.5 \times 10^6$ based on MAC
- Solver: Exa Corporation PowerFLOW® (LBM)
- Finest resolution: 8.4×10^9 cells, 6000 – 12000 cores, 7×10^6 CPU hours (NASA Pleiades), 20 – 25 days per run

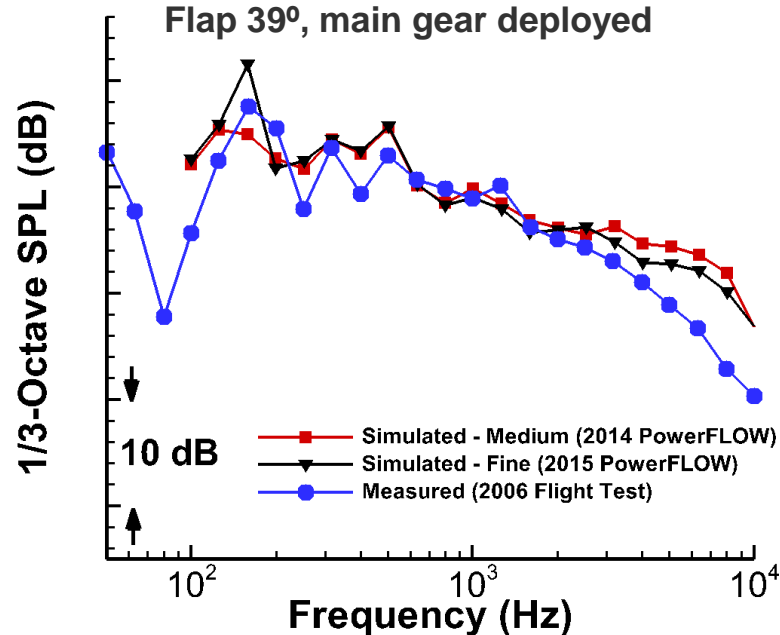
NASA-Gulfstream Airframe Noise Flight Test (2006)



Flap 39°, main gear retracted



Flap 39°, main gear deployed

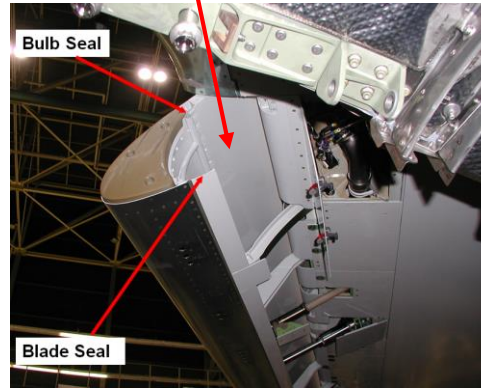


Flyover certification point
Distance of 396 feet from source

Large Civil Transport (Boeing 777)



Boeing 777 leading edge slat



Boeing 777 main landing gear

Backup Slides

